the latter than on the former; wings purplish brown; feet reddish brown.

Total length $2\frac{3}{4}$ inches; bill $\frac{5}{8}$, wing $1\frac{5}{8}$, tail $1\frac{1}{8}$, tarsi $\frac{3}{16}$.

Habitat. Citado and Pallatanga, in Ecuador.

Remark. Except in being of much smaller size, this little species is very like the black- and stout-billed *Chlorostilbon melanorhyncha*, which, in my 'Introduction to the Trochilidæ,' I have, as I now believe, erroneously placed as synonymous with *C. chrysogaster*, a bird inhabiting countries further north than Ecuador. The *C. pumilus* is also very nearly allied to the *C. assimilis* of Lawrence, but differs from that species in being still smaller, and in having a shorter and less deeply forked tail.

XXII.—*Investigations upon the Structure and Natural History of the* Vorticellæ. By Dr. Richard Greef.

[Continued from p. 112.]

External Habit of the Vorticellæ.

In general terms the external form of the individual Vorticellan animals may be described as cup-, urn-, or bell-shaped, to which latter, as the most suitable conception, the whole group is indebted for the name of bell-animalcules (*Glockenthierchen*) conferred upon it by Ehrenberg, and for the cognate denominations of tree-bells (*Carchesium*), column-bells (*Epistylis*), operculum-bells (*Opercularia*), double-bells (*Zoothamnium*), &c. According to former notions this denomination would be still more suitable, since, as is shown by nearly all the older descriptions and figures, it was supposed that the animals were hollowed like bells or cups, and furnished with cilia only on their free margin. Subsequent observations, however (first made by Ehrenberg), showed that the anterior mouth of the bell was closed by a more or less circular disk clothed with cilia, and that it was only behind this disk that a canal led, through a lateral buccal orifice, into the body of the bell, which was filled with contents, *i. e.* solid.

The anterior *ciliated disk*, or the *rotatory organ*, is externally surrounded by a broad, membranous seam, the so-called *peristome*. When the rotatory organ expands, the peristome becomes reverted, like a cushion, and is then surmounted by the extruded ciliated disk, which is frequently upon a short neck, and at the same time separated from it by a furrow (Pl. XIII. figs. 2, 6, &c.). This separation, however, occurs more or less distinctly in the different species; nay, it may be almost entirely wanting, as for example in *Epistylis flavicans*, in which the ciliated disk appears to pass directly and without any

distinctly perceptible furrow into the reverted seam of the peristome (Pls. XV. & XVI.).

The body of the Vorticellæ usually exhibits towards the middle a bellied protuberance, the anterior part being constricted behind the peristome, whilst the posterior end tapers rapidly into a wedge-shaped point. In this case the form is short and stout; but in other species the body appears elongated and without any perceptible swelling in the middle, gradually narrowing backwards from the wide, open, reverted margin of the peristome, like a tall cup or a champagne-glass. Between these two extremes, however, leaving out of consideration the changes of form produced in the same individual by the different states of contraction, we find the most multifarious transitions, sometimes most nearly approaching the bellied bell-shape, sometimes the elongated funnel-shape.

The characters of form here referred to, and the denominations of bells, funnels, cups, &c. adopted for them, of course apply only so long as the animalcules have unfolded their rotatory organ and peristome. When the ciliated disk is retracted within the body, the peristome, which was previously reverted outwards, lays itself like a cover over the former, consequently covering the whole anterior part of the body. This cover, then, in form and destination completely resembles a muscular sphincter, which, moreover, acquires a radiated appearance by means of the folds of the peristome and the cilia lying beneath it (Pl. XII. fig. 1 &c., Pl. XIII. fig. 4, Pl. XIV. fig. 6, Pl. XV. fig. 1 &c.). In these cases, of course, the form of the body is not like that of a bell or funnel, but clavate, pyriform, or even spherical.

Of the known Vorticellæ, only two genera appear to possess freedom of locomotion, namely *Astylozoon* and *Gerda*; the latter, however, which seems to have been as yet very imperfectly investigated, is limited in this faculty, or rather in the habit of constant free locomotion, as the members of this genus are characterized by Claparède and Lachmann as "Vorticellines sessiles," although in them a true adherent organ is entirely deficient. The other Vorticellæ are all fixed, either seated upon attached peduncles (*Vorticella*, *Carchesium*, *Epistylis*, *Zoothamnium*), or non-pedunculate and attaching themselves as parasites upon the soft surfaces of animals (Mollusca) by means of an organ like a sucking-disk at the posterior extremity of the body. The pedunculate *Vorticellæ* either sit singly upon simple stalks* (which in this case are always

* We here follow, for the present, the systematic arrangement of Stein, who, as already explained, has excluded from the Vorticellinæ the Ophrydinæ, among which we certainly meet with simple forms with rigid peduncles (e. g. *Cothurnia*).

contractile), and are only transitorily united two upon one stalk during division (*Vorticella*), or the stalk rises, by continual and generally dichotomous division, into an arborescent form, upon the terminal ramifications of which the individuals are united into a colony which is usually very numerous. The peduncles of these stock-forming Vorticellæ are either contractile (*Carchesium*, *Zoothamnium*) or rigid (*Epistylis*, *Opercularia*). The mode of ramification of the stock is very multifarious, and is often characteristic of the different genera and species; so that it might with advantage be made use of for systematic discrimination. A remarkable difference of this kind in the ramification of the peduncle is presented, for example, in the accompanying figures, between *Epistylis flavicans* (Pl. XV. fig. 1 &c.) and the *Zoothamnium* discovered by me in the North Sea (Pl. XIV. fig. 6 &c.). Whilst in *Epistylis flavicans* a regular dichotomous ramification ascending from the stem occurs, in the *Zoothamnium* in question the shortly pinnate branches are placed alternately upon a common shaft. Between these two very different stock-formations there are, however, a number of others, which, as already remarked, are more or less characteristic of the general habit of the species under consideration. These, however, are almost exclusively confined within the dichotomously expanded tuft- or umbel-form; the alternating branch-form has as yet been observed only in stocks of marine *Zoothamnia**.

With regard to this latter genus a remarkable peculiarity must here be mentioned, which is also characteristic of its external habit, namely the frequently very remarkable difference in size of the individuals of the stocks. Individuals may attain five or six times the size of the others, or even still more; and these then, especially when they are closed, project from the majority of smaller individuals like lumps. Sometimes there are only one or a few of these lumps, but sometimes a comparatively large number (Pl. XIV. fig. 5). They may, however, be entirely deficient†; but this, according to my observations, must be regarded as exceptional in the marine forms in question. We shall revert hereafter to this form of

* These alternating stocks were first observed by Ehrenberg in a species discovered by him in the Red Sea, and named *Zoothamnium niveum* (Die Infusionsth. &c. p. 289, pl. 29. fig. 3), then by Claparède and Lachmann in *Zoothamnium alternans* from the North Sea on the Norwegian coast (Etudes sur les Infusoires, ser. 1, p. 103, pl. 2. figs. 1–4), and finally by myself in the form which I frequently saw at Ostend and other places on the North Sea (Pl. XIV. figs. 6 & 7), which is probably identical with *Z. alternans*, but perhaps also with *Z. niveum*.

† It is very remarkable that in *Zoothamnium arbuscula*, notwithstanding the numerous examples which he examined, Stein entirely missed the lump-like animals, which Ehrenberg observed and figured in this species.

Zoothamnium, and especially to the possible relation of the lump-like animals to reproduction.

We have already indicated that, with the exception of *Astylozoon* and *Gerda*, all the Vorticellæ present only attached representatives. This attachment, and with it a limitation of locomotion, is certainly their ordinary mode of life, which governs the essential systematic character. But probably all the Vorticellæ, and certainly most of them, pass temporarily into a free life-stage, by forming the so-called hinder circlet of cilia, separating themselves from their peduncle, and swimming about freely in the water for a time, until they again attach themselves by secreting a peduncle, and at the same time very quickly lose the posterior circlet of cilia, the essential attribute of their freedom. This separation takes place either on the occasion of their division, as is always the case in *Vorticella*, as one of the divisional buds must quit the peduncle which is only intended for one individual, or particular individuals of a stock, usually when injured and disquieted in their ordinary conditions of life, spontaneously quit the colony to seek their fate elsewhere.

External Covering and Musculature.

All the Vorticellæ possess an external, hyaline and homogeneous skin, which is pretty strong in many species, which covers the whole body, passes posteriorly into the sheath of the peduncle when the latter is present, and affords the axis of the peduncle access to the base of the body, and anteriorly wraps round the peristome, clothes the ciliated disk, and is continued into and lines the nutritive canal. This skin may be brought into view in the living animals by suitable magnifying-power, but also, and generally still more distinctly, by means of various reagents (acetic acid, solution of potash, &c.), to which it offers considerable resistance. By the addition of colouring materials or iodine, also, it becomes very distinct, as it remains untouched by them and contrasts with the contents, which are rapidly and intensely coloured, and it then appears as a colourless hyaline border at the limits of the body.

Probably in all Vorticellæ this skin exhibits a regular *transverse striation* running round the whole body; and this is often so fine and close that it is detected only by a high power and close examination; sometimes, however, it shows stronger outlines. This striation has already been seen and described by Ehrenberg, and after him by many others; and with a little experience it cannot be confused with other coarser folds, also appearing in transverse rings, which are chiefly produced by sudden contraction after previous compression; for this constant, regular, and fine striation of the skin may be seen when the

animal is most fully extended, even under artificial compression, and, indeed, then often most distinctly. This difference and the fact that we have only to do here with the above-mentioned normal fine striation are of some importance, and at least merit being specially indicated here. Stein, in his most recent work on the Infusoria*, gives an interpretation of these striæ of the skin, with which, from my present observations, I cannot agree. Thus, after admitting, in correction of his previously opposite opinion, the presence of muscles in the Infusoria, founded upon W. Kühne's investigations upon the peduncular muscle of the Vorticellæ†, he thinks that, as a complement to this, the cutaneous striæ observed in many Infusoria (especially the Stentors, Spirostomes, &c.) must be interpreted as the body-muscles. It deserves to be indicated here that this opinion was distinctly expressed by Ehrenberg, who says (at p. 260 of his 'Infusionsthierchen'), in characterizing the family of the Vorticellinæ, "In some (*Vorticella*, *Carchesium*, *Opercularia*) longitudinal and transverse muscles are recognized"; and further (on p. 261), in the description of the genus *Stentor*, "The organs of motion are the innumerable cilia of the surface, together with the frontal circlet of cilia as a more special capturing organ. Visible longitudinal striæ of muscular fibres lie at the base of the longitudinal rows, but at the front circular striæ." Further, in the introduction to the "Explanations of the class Polygastrica," he says:—"Muscles can, however, be seen. These, in *Stentor*, distinctly form the base on which cilia stand, forming cloudy longitudinal striæ or spirals, &c." From all these statements it is clear that Ehrenberg regarded as muscles the same structures that Stein has recently done. We can less distinctly learn from them Ehrenberg's opinion as to the purpose of these muscles—namely, whether they are merely regarded as body-muscles which execute the contractions of the body, or as serving for the movement of the cilia—which latter notion Stein justly characterizes as erroneous with reference to our present knowledge of ciliary movement, whilst he at the same time points out that in the Infusoria generally the striation of the body and the ciliation stand in no causal connexion. The system of striæ of the Infusoria has also been interpreted by others in Stein's way and more or less completely described, as by O. Schmidt‡, who has already expressly claimed his share in it, and also by Kölliker§ and others. Excellent observations

* Der Organismus der Infusionsthiere, Abth. ii. p. 23.

† Archiv für Anat. &c. 1859, p. 824. See also the other important memoirs on the irritability of the muscles &c. in the same volume, pp. 213, 314, & 748.

‡ Archiv für mikrosk. Anat. iii. p. 391.

§ Icones histiol. p. 14.

by Lieberkühn* upon the same subject will be referred to hereafter in the closer consideration of this striation and its interpretation as muscles.

In the first place, however, we must turn once more to the above-described transverse striation in the skin of the Vorticellæ.

In the further exposition of his views, Stein applies the interpretation of the body-striæ as muscles also to the cutaneous striæ of the Vorticellæ, under which he comprehends, as his whole description shows, the above-mentioned more or less regular, fine, transverse striation. He says it is an "apparent transverse annulation; in reality it has a spiral arrangement." Moreover, if I have rightly understood the statements relating to it, the outer skin is not the real bearer of these striæ, but they are covered by the former, the so-called *cuticula*. This cuticula fulfils, with regard to the body or muscular striæ lying beneath it, the part of a sarcolemma, but envelopes them only in part—that is to say, chiefly externally and (in the longitudinal striæ) to the right and left, whilst within they are coherent with the internal sarcode of the body.

As regards the present admission by Stein of a special muscular system in the Infusoria, we can only welcome it as an essential step in advance. It seems to me that, even without the provisional morphological evidence, it must have been assumed, *à priori*, that the sudden, jerking, and convulsive movements such as we see in many Infusoria (for example, in *Spirostomum*, *Stentor*, and the Vorticellæ) could not be effected by mere formless sarcode, but only by already differentiated contractile structures—in other words, by muscular elements. Where, in those organisms in which the movements are effected only by the contractions of the formless protoplasm (therefore in the Rhizopoda and creatures like the Rhizopoda), do we find the sudden and convulsive movements of the Infusoria? In all these forms, whether they are independent or only represent states of development, the movements always appear rather in the form of a slow, uniform, and gradual flowing and creeping, the so-called amœboid movements. Although, therefore, in general the assumption of separate muscular elements in the Infusoria appears to be perfectly justified, we cannot in the special case declare our agreement with the interpretations which Stein now puts forward for the body-muscles of the Stentors, Spirostomes, &c., as also for the Vorticellæ.

* Arch. für Anat. &c. 1857, p. 403, note.

In the first place, notwithstanding many observations directed to this point, I have been unable to convince myself that the fine external transverse striation of the body already repeatedly mentioned really has a spiral course. Stein, indeed, seems only to have examined a single species as to this point, namely *Vorticella microstoma*, from which, perhaps not without warrant, he deduces the same character for the other Vorticellinæ which are furnished with striæ. In this *V. microstoma*, however, he finds "a distinct spiral arrangement;" but the ascent of the spiral is so small that the striæ deviate but little from the horizontal direction, and therefore produce the impression of a simple transverse annulation. From this admission, however, it seems to me to follow that the decision whether the striæ in question have a spiral or an annular arrangement cannot be made so easily as Stein's statements would lead one to suppose. For my own part, at any rate, I have hitherto not only been unable to detect the spiral arrangement of these striæ, but have always obtained only the impression of a regular transverse annulation, even in those forms in which the striæ have comparatively broad interspaces between them. In this inquiry I have chiefly directed my attention to the course of the striæ on the conical base of the Vorticellan body and to the anterior margin, especially when the rotatory organ was retracted into the interior of the body and the peristome covered it like a sphincter. At these two points, probably, it would be most easy to decide the question by seeking to detect the commencement or the end of the spiral line. But even here illusions may easily be produced, in consequence of the state of contraction or the position of the body at the moment. At any rate, as Stein himself admits, the ascent of the spiral, if it exists, is extremely small; so that, especially when the striæ are, besides, very fine, and follow closely upon one another (as in *Carchesium polypinum*), it can only be recognized with great difficulty by direct observation.

In the second place, also, I have hitherto been unable to convince myself that the transverse striæ of the Vorticellæ now under consideration stand in direct relation to the muscles, or rather, as Stein thinks, that these striæ are the muscles themselves; and this leads us, leaving the Vorticellæ out of consideration for the present, to a short examination of the very important question in our knowledge of the Infusoria, which has already been touched upon, of the body-muscles of these animals in general. This is the less to be dispensed with here, as Stein obtained his results with regard to the muscular striæ chiefly by observations on other Infusoria (*Stentor*,

Spirostomum, &c.), and seems only to have transferred them from these to the Vorticellæ.

With regard to this, he says*:—"The striæ (of *Spirostomum ambiguum*) consist of a homogeneous soft mass, rendered cloudy by very densely packed, extremely fine granules, and are connected with each other by means of a hyaline, firmer, but much narrower intermediate substance, which is evidently a part of the cuticula. Of course the striæ are also clothed externally by the cuticula; but it is not here separately perceptible, because it clings most intimately to the cloudy substance of the striæ." Further on, recommending the blue forms of *Stentor cæruleus* as particularly favourable for the investigation of the body-striæ, he says of it:—"The striæ here, in the broadest part of the body in large and not perfectly extended individuals, form broad ribbon-like cords, more or less strongly convex externally, which make their appearance with particular distinctness in the blue Stentors, because they are of an intense blue or verdigris colour, whilst the narrower clear interspaces remain almost colourless. In their composition the striæ consist of a homogeneous, clear fundamental substance, which cannot be distinguished from the rest of the sarcode of the body; but in this there are imbedded, close together, innumerable very fine granules, which strongly refract light and in the blue Stentors have a blue colour. The more the animals shorten themselves or widen in one spot, the broader do the striæ become; on the contrary, if the body-part extends much in length, the striæ become converted into the finest lines: the substance of the striæ must therefore be a pasty mass which flows up and down, or, if it be preferred, a viscid fluid. Even in moderately contracted Stentors, and still more in those which have contracted themselves into a spherical or pyriform shape, the striæ may be seen throughout their whole length furnished with dark transverse lines lying close behind one another, by which the striæ acquire a striking resemblance to transversely striated muscular fibres, &c."

In what follows Stein then endeavours to demonstrate the accordance of the muscular striæ of the Infusoria thus constituted with the muscular fibres of the higher animals, especially by identifying the fine granules imbedded in the body-striæ with the disdiaclasts of the transversely striated muscles, as they, even by their "very regular accumulation in groups, produce a remarkably distinct transverse striation." Finally, in order to establish the relationship completely, it is maintained, as already remarked, that the cuticula enveloping the

* Der Organismus der Infusionsth. Abth. ii. p. 28.

body-striæ is analogous to the sarcolemma of the muscular fibres.

From the above it will be seen that the question about the muscles of the Infusoria is answered by Stein in great detail and very definitely; and if the answer were correct we should have made an essential step forward in the knowledge of the organization of the Infusoria. But my observations compel me to advance doubts with respect to the main points in Stein's statements. If we examine *Stentor cæruleus*, which is justly recommended by Stein for investigation with regard to the question before us, we see without any trouble the well-known regular longitudinal striæ running from before backward over the whole surface, and, indeed, alternately *a very narrow, pale, and perfectly homogeneous stria*, resembling a pale line or *furrow* drawn along the whole length, and *a broad ribbon-like stria*, in which *many fine granules* of various sizes are scattered, and which consequently, in contrast with the pale striæ, acquires a *cloudy* appearance. The broad cloudy bands thus appear to be enclosed and shut off from each other by the pale threads. According to Stein's view, above explained, the former represent the true muscles, whilst the pale lines are merely non-contractile connective substance, the cement which unites the muscular striæ with each other.

To me, however, all the characters seem to speak in favour of the reverse condition—namely, that the narrow pale striæ are the true muscles, and the broad cloudy bands form the connective substance. Lieberkühn* has already expressed this opinion with regard to the body-striæ of the Stentors; and the observations cited by him in support of it are so convincing that it cannot but appear surprising that Stein should briefly, and without sufficient reasons against them, set them aside for the benefit of his own theory. Lieberkühn, after mentioning the broad richly granular striæ of the Stentors, already described by Ehrenberg, says:—"But there is yet another system of striæ which behave like muscles, inasmuch as they are endowed with the property described by Edward Weber as belonging to muscles—namely, that in a state of repose they acquire a serpentine form, and extend themselves straight during contraction. They are sharply contoured fibres, free from granules, of about the breadth of the non-granular interspaces, beneath which they run in the direction of the long axis of the body; they are attached in front below the great circlet of cilia, and behind at the 'sucking-disk;' some of them unite during their course. The changes occur-

* Archiv für Anat. &c. 1857, p. 403, note.

ing during contraction are most distinctly seen when a colourless or slightly coloured Stentor lies exactly in such a position that one looks upon the circular sucking-disk; we then see, in a state of repose, all the separate muscles starting from its circumference in a serpentine form; but at the moment when the animal jerks itself together and therefore shortens itself, the serpentine form disappears entirely, and the muscles become straight. The straight muscles immediately begin to relax again, and to fall back into the serpentine form, and the Stentor again elongates itself."

Lieberkühn, therefore, interprets the pale striæ as sharply contoured muscular fibres, whilst Stein regards them as mere furrows formed by the cuticula, which have nothing to do with muscles, and which, under certain states of contraction, only apparently occur as "limpid fibres bounded by double contours," but in reality are portions of the cuticula folded in like a groove.

The decision of this point, however, seems to me not to be very difficult by careful and unprejudiced examination. If we once more examine our *Stentor cæruleus* we see that the two systems of striæ are certainly of completely different nature; the broad streaks consist of a softer mass, more or less darkened by imbedded blue pigment-granules, and the narrow ones of a firmer hyaline mass destitute of granules.

Now, as regards the substance of the broad streaks, in the first place we see in them, with the exception of the numerous irregularly scattered granules, no trace of special formative elements, or special structural conditions, and especially nowhere any *formation of fibres or cells*, either in the fresh state or after artificial treatment. What is there to compel us to regard these striæ as comparatively highly differentiated muscular substance, even comparable to the transversely striated muscles of the higher animals? According to Stein, the strongly refractive granules imbedded in the mass are to be considered to represent the enigmatical disdiaclasts of the transversely striated muscles. But with what justice, we must ask, can we regard the granules which occur in almost every thing that is called protoplasm, and indeed almost constitute a characteristic constituent of it, as equivalent to the disdiaclasts of the transversely striated muscular fibres? Where are the sarcous elements constituted by the disdiaclasts? Where are the true *muscular fibres*? How is the property of double refraction, which is characteristic of the disdiaclasts, demonstrated? And, lastly, where do we find a distinct longitudinal and transverse striation? Stein remarks that during strong contractions dark transverse lines are produced, by which the striæ acquire a striking resemblance to the transversely striated muscular

fibres*. But is it not more natural to regard the dark transverse lines as having been produced by the granules being pushed together by pressure during the contractions, which are often sudden and strong, towards the crests of the transverse ridges or tubercles, and here grouped in more or less regular streaks? Moreover it is to be borne in mind that the transverse streaks in question make their appearance, especially in the anterior part of the body, in the neighbourhood of the peristome. Here, however, *actual circular lines* run round the whole body, perhaps representing special circular muscular fibres. We can therefore find nothing to justify us in regarding the broad striæ in question as muscular substance. It seems much more feasible to regard them as a part of the so-called *cortical layer* of the Infusorian body, which envelopes the muscles and other organs and fixes them in their places; to its signification in the Infusorian organism we shall revert more in detail hereafter. Moreover, for the granules made use of by Stein in his theory we have a purpose, which has already been pointed out, and seems to me to be satisfactory: they are the *bearers of the blue colouring-matter* which renders the *Stentor cæruleus* immediately recognizable, especially in the midst of the usually predominant society of the green *Stentor polymorphus*. They are, therefore, as Stein himself states, *pigment-granules* situated beneath the cuticula; and just as little as this property can be denied to them does it seem to me that any other one has been demonstrated for them.

Let us now turn to the second system of striæ, which run, in the form of clear narrow lines, alternately with the striæ just referred to, and, like these, along the whole length of the body, and which, as has already been explained, are regarded by Stein as the connective substance of his muscular streaks. They certainly at first produce the impression of clear, groove-like, cutaneous striæ which are stretched out between the dark streaks; but on more careful examination we find that *beneath each of these clear lines runs a powerful hyaline thread*, which, as we may ascertain most decidedly, can never be the expresssion of the "cuticula folded in like a groove." This is characteristically shown, in the first place, by the *tortuosity of the thread* in a state of repose already described by Lieberkühn, and which is particularly beautifully seen in the hinder part of the body. Against this Stein urges that the same thing occurs

* Stein has overlooked the fact that this transverse striation, to which he gives so much prominence, has been already observed and illustrated by Kölliker, with a figure (Icones histiol. p. 14, pl. 1. fig. 12), which leaves no doubt that Kölliker had before him exactly the same phenomenon as Stein.

also in the broad streaks, which are just as undulated and tortuous as the lines bounding them. This statement, however, depends upon an erroneous observation; for it is only the narrow filaments that have a truly serpentine course, passing right and left out of their lines and into the substance of the neighbouring soft and broad streaks, sometimes narrowing them to a very small space when the convexities of two convolutions approach each other, and sometimes widening them. By this means the broad streaks acquire rather a repeatedly sinuated, necklace-like appearance than a serpentine one. Is such an extended and regular approximated tortuosity of sharply contoured filaments such as we have before us in *Stentor* at all conceivable, except with the existence of actual filamentous structures? If the clear streaks were, as Stein thinks, only a part of the cuticula, and if the filaments were produced only by its folding, they could hardly follow so regularly serpentine a course without the production of folds on the other parts of the surface of the body, as the cuticula also covers the broad streaks. How, moreover, could the sudden disappearance of the loops of the filaments (that is to say, the shortening of the filaments during a sudden contraction of the body), already described by Lieberkühn, be explained? If they were in reality folds of the skin, must they not then exhibit more numerous and larger loops? Besides we may even see the clear narrow stripes of cuticula pass in a straight direction over the subjacent undulated filament, so that there can no longer be any doubt as to the presence and position of the latter.

A further argument against Stein's view is to be found in the *reticulate ramification of these filaments*, which is almost always observable at the posterior extremity of the body, two neighbouring filaments before attaining the posterior extremity becoming united into a single one, whilst the broad body-striæ enclosed by them go no further, but terminate in a wedge-shaped form in the angle of union. The filaments thus united then often divide again in their further course, and again amalgamate with other neighbouring filaments, and in this way form an actual reticulate ramification. The extremities of these filaments, whether reticulately united or running singly, always attain the posterior extremity of the body ("sucking-disk") and attach themselves there. But the broad bands neither form a network nor do they all reach the posterior extremity of the body; they frequently terminate before it without uniting with their neighbours, nay, often forming mere wedge-shaped pieces between the clear striæ. The broad bands form merely the partially enveloping connective substance of the clear threads, and not *vice versâ* as Stein thinks.

If a Stentor be carefully crushed under the glass cover, we see, as the contents of the body flow out, the filaments under discussion projecting here and there isolatedly from the edges, and are able to trace them thence continuously into the remaining body. At some points even the filaments are torn on this occasion, and we may then observe how their viscid hyaline substance contracts into thickened bacillar portions. By this the muscular filaments of the Stentors approach very closely to the axial filaments in the stems of the *Vorticellæ*, with which I should be most inclined to compare these structures as regards their whole appearance, behaviour, and consistence.

By other artificial methods also, especially by the addition of alcohol, we may ascertain the resistance and independence of the filaments, and that they by no means form a part of the cuticula.

It would, however, lead us too far from our present task if we were to cite any more details in support of our view. We believe that, from what has been stated, we may attain a conviction that it is not, as Stein believes, the broad, granular, longitudinal striæ, but the *narrow*, *clear*, *longitudinal lines* that form the body-muscles of the Infusoria.

We now revert to our Vorticellæ, and must, in the first place, again refer to the fine transverse striæ already mentioned (p. 199), to which, as may be remembered, Stein has ascribed (1st) a spiral course, and (2nd) the properties of muscular fibres. With regard to the first point we have already put forward our doubts, and stated that we think these striæ must be regarded as not spiral but circular, and consequently as annulations following closely one upon another. But in the second point also we cannot agree with Stein. The fine external transverse striæ of the Vorticellæ belong rather, in our opinion, to the external skin, and can by no means be brought, as Stein will have them, into connexion with the longitudinal or muscular striæ of the Stentors and Spirostomes. *The muscles* of the Vorticellan body are rather situated *beneath the transverse striæ*, and have, for the most part, a very different course from these, namely in the *longitudinal direction* of the body, just as is the case also in the other Infusoria. Of this we may best convince ourselves when we examine the hinder part of the body of a Vorticellan under careful compression. The longitudinal fibres, radiating forward from the conical base, make their appearance here very distinctly (Pl. XV. fig. 5 *g*, & Pl. XVI. fig. 1). They become still more perceptible when we are able to examine an animal separated from the peduncle in such a position that the base of the body is turned directly upwards towards the eye; the fibres are then seen radiating

on all sides from the circular point of attachment of the peduncle. In this position of the animal, especially when, without being compressed, it rests with its opened anterior ciliated disk upon the glass plate and stretches its base upwards, we may also obtain, in certain positions, the clear view of a transverse section of the body (see Pl. XIV. fig. 8). At the outside there appears a *clear border* (*cuticula*), which is distinctly limited within; then follows a circlet of *dimly shining corpuscles* (the *lumina of the muscular fibres*), and further in, again, a *clear zone* (*cortical layer*), which, as *parenchyma, entirely fills* the conical hinder part of the body, but becomes thinner anteriorly, and encloses the true *body-cavity*. Within the last clear layer of parenchyma we then see, in Vorticellæ with contractile pedunclcs, some dark corpuscles arranged in a circlet; these may be regarded as the fibres of the peduncular muscles radiating in the body.

If the body of a Vorticellan be gradually compressed until it is completely flattened, granules, all of the same size and in apparently regular arrangement, make their appearance beneath the cuticula. In general we seem to recognize a distinct longitudinal direction, corresponding to the course of the muscular fibres (Pl. XIV. figs. 1, 5); but it is very possible that this is an illusion, as the longitudinal fibres of the muscles appear at the same time and in the same place. Sometimes, also, especially during long-continued compression, it is difficult to ascertain that they have any definite direction. Whether they can be brought into connexion with the muscles, or whether they belong to the lower surface of the cuticula, or, lastly, to the cortical layer of the body, I cannot decide at present. These are, no doubt, the same structures already mentioned by Leydig *, and which appeared to him to have "quite the habit of nuclei." I admit that on viewing these peculiar corpuscles, their regular arrangement and their always definite size and limitation, I was frequently inclined to adopt the opinion of this distinguished naturalist, and to regard them as the nuclei of the cortical layer or of the muscles. But for this it is necessary, in the first place, to accept the supposition that nuclei and cells of such minuteness as the corpuscles in question really exist, which, although we cannot reject it out of hand, is yet by no means founded upon observation. Perhaps, however, further investigation, especially upon the development of the Vorticellæ, may furnish an answer to this question, which is by no means unimportant towards our conception of the structure and, through this, of the position of these animalcules.

* Lehrbuch der Histologie des Mensch. und der Thiere, pp. 16 & 125.

Besides the longitudinal fibres, we find in the ciliated disk and in the peristome circular fibres; but in these parts, also, I have been unable to make out whether they have a spiral course corresponding with that of the ciliary spiral.

To the skin and the above-described muscles a protoplasmic zone adheres within on all sides—the true *cortical layer* of the Infusorian body, which encloses and lines the whole internal space or *body-cavity*, upon the nature and signification of which we shall shortly go into detail. If a Vorticellan be slowly compressed under the glass cover, by abstraction of water we see, especially at the moment of its death, a distinct vesicular and often almost regularly polygonal marking (*Epistylis flavicans*) make its appearance beneath the skin. This belongs to the above-mentioned cortical layer of the body. Whether this vesicular arrangement of the protoplasm exists during life, or only makes its appearance after death, I have been unable to ascertain positively. In this cortical layer, and held by it in their position, are seated the principal organs of the body, namely the nucleus, the contractile vesicle, and the principal section of the alimentary canal, which we shall also consider more particularly hereafter.

Finally, I must here refer to the exceedingly peculiar structures situated beneath the skin, of which a passing mention has already been made, with the indication that they ought possibly to be regarded as urticating organs. I have hitherto found these organs only in *Epistylis flavicans*, and even here not constantly; in connexion with which, however, it must be remarked that very probably several species, or at any rate varieties, have hitherto been included under the above name. The bodies in question are *oval or pyriform, sharply contoured, shining capsules*, which almost always lie together in pairs, and apparently in the cortical layer (Pl. XV. figs. 5 *k*, 7, & 8). They are of great firmness, and present great resistance to caustic potash and the like; but if they are removed from the body and compressed, a *tolerably long and powerful thread springs forth from each of the capsules* (Pl. XV. figs. 7 & 8 *b*), and generally from the somewhat pointed end, which, in the above comparison, represents the stalk-end of the pear. The expelled thread usually forms several convolutions and loops, is motionless, and shows no special structural characters; by careful examination it may also be seen rolled up, apparently in a spiral, in the interior of the still closed capsule (Pl. XV. fig. 7 *a*). What is the interpretation of these structures? Are they proper to the Vorticellan body and formed in it? or are they foreign organisms which have penetrated into it? In the

latter case they would perhaps represent a *parasitic fungus*, certainly deviating from all at present known; in the former I do not know how to interpret them, except as *urticating organs*, which would exhibit an extremely remarkable agreement with the urticating organs of the Cœlenterata. Although I am inclined to the latter view, I would leave the decision to further investigations, which should be directed especially to the genesis of these bodies. If it should prove that these structures are really urticating organs belonging to the Vorticellan body, this would be of the greatest importance to our knowledge of the structure of the Infusorian body, as these urticating capsules, considering their perfect agreement with those of the Cœlenterata, would undoubtedly be developed, like the latter, *from cells*.

[To be continued.]

XXIII.—*On the Nomenclature of the Foraminifera.* By W. K. Parker, F.R.S., and Prof. T. Rupert Jones, F.G.S.

[Continued from vol. viii. p. 266.]

Part XV. *The Species figured by Ehrenberg.*

Contents.

§ 1. Amongst the most enthusiastic observers and voluminous writers on Foraminifera Dr. Ch. G. Ehrenberg stands pre-eminent. By the end of the year 1838 he had reduced to order the multitudinous specimens of recent and fossil Microphytes and Microzoa which he had either gathered, with Dr. Hemprich, in the East or had received from numerous correspondents. Among the results is the Tabular Classification* of his Bryozoa (*Polythalamia*, *Gymnocoræ*, *Thallopoda*, and *Sceleropodia*), which, mingling Foraminifera and Polyzoa,

* Table opposite p. 120, 'Abhandl.' für 1838.